

SP-G1 Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam

October 25, 2002

1.0 Introduction/Background

Dams affect upriver geomorphic processes. These processes include physical attributes and functions such as channel shape, channel stability, sediment transport and deposition, and bedload recruitment. This is caused by the lake, which changes the local base level. As the lake level changes from day to day and from year to year, the upstream channel responds with channel aggradation or degradation. This creates a highly dynamic reach immediately upstream of the reservoir that can affect riparian vegetation, fish, aquatic invertebrates, and other resources.

Fluctuating base level also affects substrate scour or deposition, mobilization of sediment, turbidity levels in the lake and its drawdown zone. When lake levels are high, sediment deposits in the upper reaches of the lake) Sediment is subsequently eroded in the spring and summer when lake levels are lower, causing large amounts of sediment to move. In addition, wave action can erode shorelines during winter storms when lake levels are high. Boat wakes and storms in other seasons could also increase turbidity. High turbidity and sediment movement affects the reservoir's benthic invertebrates, riparian vegetation, and fish. The sediment deposits sometimes create fish spawning migration barriers, particularly in small tributaries entering the lake.

2.0 Study Objective

To determine ongoing project operation effects (primarily seasonal water level changes) on reservoir sedimentation, mass wasting, shoreline erosion, channel geomorphology, and sediment transport in the Feather River in and above Lake Oroville. This information will be provided to other studies to be included in their evaluations of the Oroville Facilities ongoing effects on riparian resources, water quality, fish, and wildlife. Components of sediment mass balance studies include:

1. Determine sediment conditions and sediment transport requirements.
2. Evaluate sediment sources (including tributaries) and conditions.
3. Map major sediment deposits.
4. Evaluate upstream channel stability.
5. Evaluate ongoing project-affected sediment regimes.
6. Quantify and characterize sediment volume and grain size variation in Lake Oroville (explain why in methodology).

3.0 Relationship to Relicensing/Need for Study

Relicensing participants have identified the altered sediment routing and reservoir drawdown caused by the Oroville Facilities as potential project effects on the river above the lake.

The following project-related structures and operations can adversely impact sediment transport regimes: diversions, reservoirs, channels with flow augmentation, tailraces, roads, sluicing/sediment removal practices, rock drops, surge chamber discharge, spillways/forebay overflow, and instream structures. These structures can result in the storage of sediments or the discharge of greater quantities of sediment than would occur under natural conditions.

The geomorphic investigation will compare historical and current conditions to help quantify ongoing project affects.. This information will help address continuing effects to native plant and animal habitats and riparian resources from hydrologic, channel, and sediment routing changes. These data, together with other study results, will provide boundary conditions for identifying and assessing potential management actions.

4.0 Study Area

The study area includes the reservoir, the fluctuation zone, and the tributaries that are influenced by the fluctuation of lake levels. The effects of fluctuations can extend to the next salmonid migration barrier upstream of the lake, such as the Big Bend Dam on the North Fork Feather. On the Middle Fork, the study area will extend to the first upstream migration barrier or to the limit of observable geomorphic effects upstream from the lake. The specifics of the upstream extent and numbers of tributaries will be based on initial survey results of the reservoir shoreline exposed during low water conditions. Study plans approved by the Environmental Work Group define the limits of the study area. If initial study results indicate that the study area should be expanded or contracted, the Environmental Work Group will discuss the basis for change and revise the study area as appropriate.

5.0 General Approach

The study methodology consists of 7 individual tasks. If initial study results indicate that the methods and tasks should be modified, the Environmental Work Group will discuss the basis for change and revise the study plans as appropriate.

Task 1—Obtain and Review Existing Resource Data

DWR will compile previous work using the State Resources Agency Library and extensive in-house publications. Hydrologic and cross-section data will be compiled. A set of base maps and photos will be obtained for plotting the data.

A set of these maps is in the DWR map library. These maps will be used to compare historic and existing conditions to assess ongoing project affects.

Available photography will be compiled for use in charting changes in stream morphology, vegetation, land use, and other data. The most recent photography will be ortho-corrected and used as a base for a Geographic Information System. If recent photography is not available, it will be obtained with new flights.

Previous information dealing with the Feather River above Oroville Dam will be collected. This includes reports on sediment, landslides, watershed attributes, stream morphology, and others. Historic gauging station data from gages directly upstream of the lake will be compiled.

Subtasks and products under Task 1 include the following:

- Consult with county, state, and federal agencies, including DFG, CDMG, USFWS, USFS, NMF, USGS, USACE, and USBR. Consult with companies and private individuals having knowledge of the geology and geomorphic processes in Study Area.
- Perform initial survey of reservoir shoreline noting the location of sediment deposits, deltas, and bars at or above the water line and relationship to tributary streams.
- Review of previous work will include compiling data sets, assessing the adequacy of the data, and identifying data gaps.
- Prepare a general description of the physiographic setting, including maps of precipitation, geology, soils, topography, vegetation, and other watershed characteristics upstream of the dam. Most of this information is available and can be modified from existing DWR and USFS reports.
- Compile from published sources information on large-scale geomorphic processes and disturbances within the watershed. These include large flood events, volcanic eruptions, mass wasting, and glacial activity. It will also include human-induced events, such as deforestation, hydraulic mining, urbanization, dam building, diversions, and others. These events influence reservoir life, sedimentation, turbidity, storage, and fish.
- Prepare maps and tables showing the sediment sources in the watershed and the relative amounts produced by the North, Middle, and South forks.
- Classify upstream reaches within the sphere of influence of the lake, using the Rosgen stream classification system. The reaches will be classified using Rosgen's Level I stream typing, then further classified using the Level II or higher classification based on channel form and substrate. The results of the stream classification and data collection will be presented on the river atlas and GIS system.
- Access historic information (timber salvage, effort required for removal, etc.) related to woody debris input to reservoir

Task 2—Map the Channel Resources in the Tributaries above Oroville Dam

DWR will measure the geomorphic channel characteristics of the West Branch, North Fork, Middle Fork, South Fork and other tributaries, identified during the initial survey as being influenced by reservoir-induced backwater effects, shoreline erosion, and mass wasting. Study methodology, computer model selection, and other parameters will be selected depending on Task 1 findings. Geomorphic parameters include channel width, depth, cross-section, hydraulic radius, roughness, large woody debris, gravel bars, islands, and others. Cross-sections will be surveyed at impacted areas identified as having a deleterious buildup of sediment or excessive erosion. The spacing and level of detail will be selected based on the magnitude of the impacted area. Some cross-sections will be surveyed, but intermediate ones may be developed using sonar and GPS during high lake levels. The end-points will be permanently marked using steel pipe set in concrete monuments. Each cross-section will have a photo point, and additional photo points will be established in critical areas.

Pools, riffles, and runs will be mapped. Representative areas at the riffles will be analyzed using bulk gravel sampling and surface sampling techniques to determine the surface and substrate quality of spawning gravel. Gradation curves for each riffle will be prepared. These data are particularly important in evaluating project effects on fish and the riparian community.

Subtasks and products under Task 2 include the following:

- Prepare an aerial photo atlas using recent, rectified aerial photos. These will be used as a base layer for the GIS system.
- Establish baselines, locate benchmarks and existing cross-sections, and set monuments. Survey monuments using GPS.
- Survey channel cross-sections using a tagline strung between the endpoints. Vertical measurements will be taken every ten feet and at topographic break points. The river portion will be surveyed using a small boat. The roughness coefficient and bed material size will be estimated for each cross-section.
- Conduct Wolman gravel sampling at representative cross-sections and tabulate data to compare with acceptable limits for spawning gravel.
- Describe the features of tributary inputs,
- Evaluate the presence/absence of active and/or remnant deltas at confluences with main stem and reservoir.
- Describe the sediment characteristics of tributary inputs: lithology, grain sizes, and stratigraphy of deposits.
- Map and characterize sediment sources and deposits.
- Describe the type of sediment (size class based on visual observation for areas between cross-sections).
- Estimate the approximate thickness of sediment accumulations.

For the reservoir, the following will be described in the field: 1) location and estimated volume of visible sediment deposits; and, 2) effects of wave erosion on turbidity. In addition, project operations data regarding reservoir sediment and history will be collected and reviewed.

For each major reservoir arm, a bathymetric survey will be conducted using a digital echosounder and GPS combination. Information collected from these surveys will be entered into GIS for map production and area calculations at different elevations. Reservoir substrates will be characterized at low lake elevations and by grab samples in deeper locations. These and additional reservoir habitat data described below, also will be added to the GIS. Shoreline steepness will be measured from reservoir morphometry and bathymetry.

Task 3—Re-Survey Reservoir Cross-Sections and Determine Sediment in Storage

This task will consist of two parts. The first part consists of monitoring sediment in Lake Oroville to determine the amount of sediment the dam stops from going downstream. Cross-sections were surveyed prior to dam construction in the early 1960's, in 1973, and again in 1994. A large storm in January 1997 brought a large slug of new sediment into the lake. The lake would be re-surveyed as part of this project to determine the total amount of sediment deposited to date.

The second part of Task 3 would consist of determining sediment sources derived from the lake. These include reservoir shoreline erosion and mass wasting. Shoreline erosion would be measured by comparing soil profiles and other evidence above and below the high water level. Areas of instability would be identified from aerial map survey and delineated on a slope stability map.

The map would be of a scale sufficient to make an estimate of sediment volume contributed by mass wasting events. Some areas of slope instability would be instrumented to evaluate rates of movement.

Subtasks and products under Task 3 include the following:

- Compile and digitize cross-sections surveyed in the mid-1960s, 1973, and 1994.
- Re-survey cross-sections to determine change since 1994, and use these data to determine long-term sedimentation rates.
- Map shoreline erosion and estimate sediment amount derived from this source. In some areas, bank erosion will be measured in detail using erosion pins and cross-section surveys. This information will be provided to other studies to include in their evaluation of on-going project effects on lake turbidity, sediment, recreation, cultural resource, and vegetation.
- Map areas of slope instability in directly affected stream reaches above the dam and within the reservoir. Instrument some of these areas to determine rates of landslide movement. Estimate sediment derived directly from mass wasting events.

Task 4—Cross-Section Monitoring

Cross-section locations will be monitored during the length of the study to measure changes in geomorphic characteristics and to chart sediment degradation, aggradation, and movement within the reservoir area. A few will be selected based on the hydraulics of the stream flow, magnitude of impacted area, and sediment characteristics to measure hydraulic and sediment transport conditions at a variety of flow rates when the lake is low. The monitoring will include setting a tag line between the cross-section monuments; measuring the depth and stream velocity; measuring bedload transport using a Helley-Smith bedload sampler; measuring temperature; measuring the wetted hydraulic radius; and other stream parameters as necessary. This will assist in evaluating geomorphic changes affecting habitat in this important interface between river and lake.

Subtasks and products under Task 4 include the following:

- Collect existing survey, topographic, and photographic data. Survey cross-section using a tagline strung between the endpoints. Vertical measurements will be taken every ten feet and at topographic break points. The river portion will be surveyed using a small boat. The roughness coefficient and bed material size will be estimated for each cross-section.
- Conduct monitoring activities at representative low, medium, and high flows to cover the full spectrum of streamflow and sediment transport. This should be done during low reservoir levels when most of the river is actively flowing.
- Measure temperature, depth, velocity, turbidity, bedload movement, and suspended sediment across the cross-section using standard U.S. Geological Survey methodology.
- Prepare graphs, tables, and charts showing streamflow, temperature, turbidity, sediment discharge, bedload and suspended sediment size distribution.

Task 5—Determine Changes in River Geomorphic and Hydraulic Parameters

Available past cross-sectional data will be compared to data collected under Task 3 to determine upstream changes in channel shape, form, and function caused by the dam. Changes in depth, width, hydraulic radius, roughness, gradient, pool-riffle-run ratio, and other hydraulic parameters will be determined.

A conceptual sediment budget will be developed for the streams and reservoirs upstream of Oroville Dam based upon the results of Tasks 1 and 2. The budget will identify locations, types, and relative magnitudes of sediment sources, and describe the location, volume, and trapping status of sediment traps (reservoirs and other impoundments). The budget will help identify geographic locations subject to project related effects. Determine average ongoing effects of Oroville Dam by comparing historic and ongoing sediment transport, gravel bars, riffles, channel width, gradient and other geomorphic characteristics using maps, photographs, and surveys. Prepare figures, graphs, and charts showing the changes.

Reservoir bathymetry mapped as part of this study (Task 3) will be compared to previous bathymetry, when available, and pre-reservoir topography. In addition to volume comparison, reservoir profiles will be evaluated to locate areas of sediment deposition, if any. Where possible, the type and character of these sediment deposits will be assessed visually when the reservoirs are drawn down during the late fall and early winter months.

Task 6—Prepare Draft Report

The Draft Report will allow for comments, corrections, and additional data in preparation of the Final Report.

Task 7—Prepare Final Report

The Final Report will include the main report with an introduction, previous work, procedures, description of work done, comparative tables, results, summary, conclusions, and information to be used to develop recommendations. A river and lake atlas will also be prepared with recent, ortho- corrected photography at a scale of 1 inch = 500 feet. Locations of riffles, pools, runs, cross-sections, monuments, sample areas, photo points, and other data will be shown. The collected data will be compiled into a Geographic Information System (GIS) database. This will allow the data to be presented in both atlas and electronic form. The GIS will also allow additional information to be added and presented at a later date.

6.0 Results and Products/Deliverables

A draft and final report will be prepared and included:

- Executive Summary
- Table of Contents
- List of Tables
- List of Figures
- Introduction
- Approach
- Narratives of relevant findings by task

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- Discussion addressing most relevant questions (see above) and indicating any complications/data concerns
 - Conclusions related to study plan goals and objectives
 - References
 - Appendices

The study will be used to identify ongoing project affects on the hydraulic, geomorphic, and sediment transport characteristics of tributaries and the lake above Oroville Dam. The effect of the changes on fish, flooding, riparian vegetation, and invertebrates will be assessed in other studies. Results of the study will help identify potential protection, mitigation and enhancement actions for the relicensing process.

7.0 Coordination and Implementation Strategy

Coordination with Other Resource Areas/Studies

It is anticipated that this study will require coordination with those individuals and agencies responsible for collecting water quality, stream flow, temperature, fishery, habitat, cultural resource, recreation, and project operation data, and performing biological surveys, and fishery studies.

Implementation of this study plan will require coordination with other Oroville relicensing studies as follows: historic air photos, riparian habitat mapping and occurrence data (SP-T4); Effects in the Fluctuation Zone (SP-T3); Contaminant Accumulation (SP- W-2), Effects on Reservoir Fish Habitat (SP-F3), historical and alternative operations data will be obtained (SP-EO2); and description of recreation use (SP-RS03). This study will also require coordination with the GIS program.

This study fully or partially addresses the following Stakeholder issues:

Stakeholder issues fully addressed by SP-G1 Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam

- GE19—gravel recruitment impacts of the dam – both up and down stream;
- GE22—effect of accumulated sediment on lake bathymetry of Lake Oroville;

Stakeholder issues partially addressed by SP-G1 Effects of Project Operations on Geomorphic Processes Upstream of Oroville Dam

- W6—effect of existing and future project facilities and operations on sediment deposition and potential impoundment of metals and toxins, including the potential presence and uptake of methyl mercury through the food chain. Lake Oroville, fed by tributaries that have a history of gold mining activity, has potential for accumulation of elemental mercury in its basin sediments;

Other issues addressed by this study plan are included in Geology Issue Statement 1, which included the following Issues:

DIRECT

- GE10—has the project resulted in sediment starvation (e.g., reduced gravel recruitment) to the lower river, and if so, by how much;
- GE19—gravel recruitment impacts of the dam – both up and down stream;
- GE24—direct, indirect, and cumulative impacts of project facilities and operations on sediment movement and deposition, river geometry, and channel characteristics. This includes impacts on stream competence, capacity, bank stability and extent, duration, and repetition of high flow events;
- F6—effects of existing and future project operations on sediment deposition, erosion, and recruitment through the system (including downstream sediment supply) and associated changes in water quality on the quantity and quality of aquatic habitats within project affected waters;

INDIRECT

- GE25—Natural geomorphologic processes historically occurred within the Feather River watershed and are the result of geologic and hydrologic processes such as weathering, erosion, runoff patterns, material transport and deposition. Project features and operations have altered these natural geomorphic processes. Alteration of these geomorphic processes has affected the riverine habitat and species that depend on it. The FWS is concerned that project operations may have taken us beyond some critical thresholds for ecosystem sustainability.
- We are concerned that maintenance of a satisfactory abiotic template (e.g., substrate used for invertebrate production and fish spawning) is not occurring). The FWS wants assurance that new license conditions will allow for minimum thresholds of geomorphic processes to take place thus ensuring sufficient natural sediment movement and a satisfactory abiotic habitat template are in place;
- F1—effects of existing and future project operations (including power generation, water storage, ramping rates, and releases, pump-back, water levels, and water level fluctuations) during all water year types on the behavior (e.g., migration timing, microhabitat selection, vulnerability to predators), reproduction, survival and habitat of warm- and cold-water fish and other aquatic resources (e.g., macroinvertebrates), which include in project waters and tributaries within the project boundaries (Lake Oroville, Diversion Pool, Fish Barrier Pool, Forebay, Afterbay, Oroville Wildlife Area), and in project affected waters;
- F3—project effects on resident fish species (e.g., trout and other salmonids and warm-water fish) habitat quantity and quality (including instream flow, sediment, woody debris, water temperature, etc.) and habitat for other aquatic species;
- FE9—use Instream Flow Incremental Methodology (IFIM) or a comparable methodology to determine streamflow needs to ensure that trout habitat quality and quantity are not reduced within Study Area and/or project affected areas;
- FE11—Inventory streams, streamside areas, and other wetlands in deteriorating condition and restore on a priority basis within Study Area and/or project affected areas;
- FE14—provide for fish passage and maintain natural channel character at stream crossings within Study Area and/or project affected areas;
- FE38—preserve natural riparian flood control abilities. Remove only those log jams or major debris accumulations that have a high potential of causing channel damage, block fish passage, or could be transported downstream by high flows and cause loss of property;
- T3—effects of existing and future project operations on floodplains and project water fluctuation zones, including soil stability, wildlife habitat and natural flood control functions, revegetation of native plant communities, and restoration opportunities (e.g., red willow planting);

8.0 Study Schedule

The initial aerial survey of the reservoir area was conducted during October 2001. Cross-section surveys will be conducted from March through August of 2002. Gravel sampling and geomorphic mapping will be accomplished during the same period. Monitoring cross-section locations will occur during late 2002- early 2003. Follow-up surveys will be completed in Fall 2003 if needed. An atlas, maps, surveys, and the GIS will be produced concurrently during the studies and should be completed by the summer of 2004. The final report would be completed by December 2004.

9.0 References

- Andrews, E. D. and J. M. Nankervis. 1995. Effective discharge and the design of channel maintenance flow for Gravel-bed Rivers. In: Natural and Anthropogenic Influences in Fluvial Morphology, American Geophysical Union, and Geophysical Monograph 89.
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